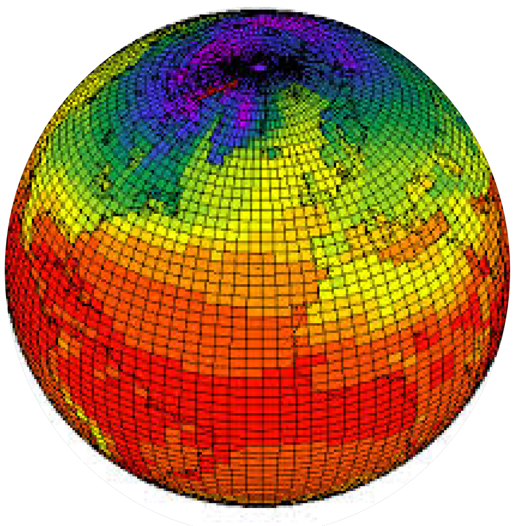
Traditional evaluation perspective

Model



Observations

Reality

Curtosy Dirk Notz

A shift in the paradigm

Reality

Model A

Observation A

Observation B

Curtosy Dirk Notz

A traditional verification question

Is model system B superior to model system A?

A	B
Low horizontal resolution	High horizontal resolution

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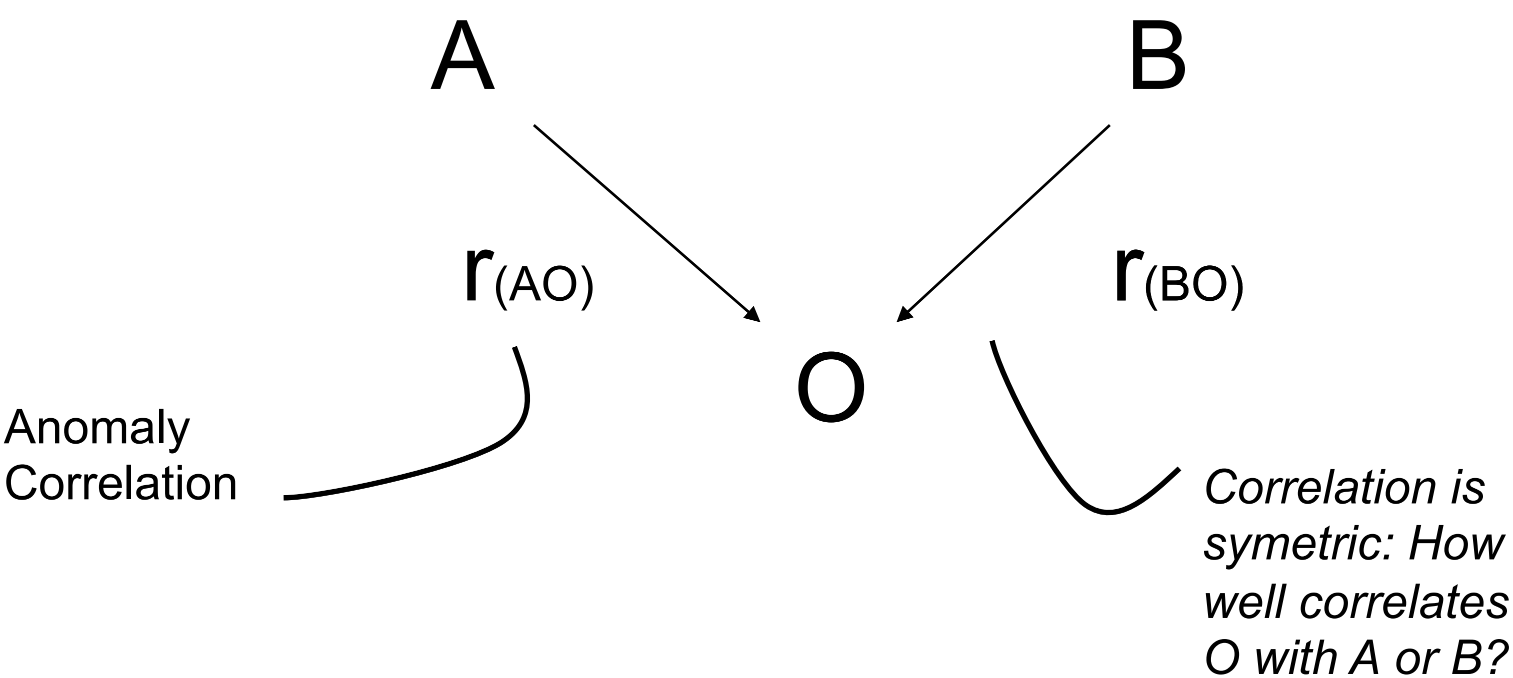
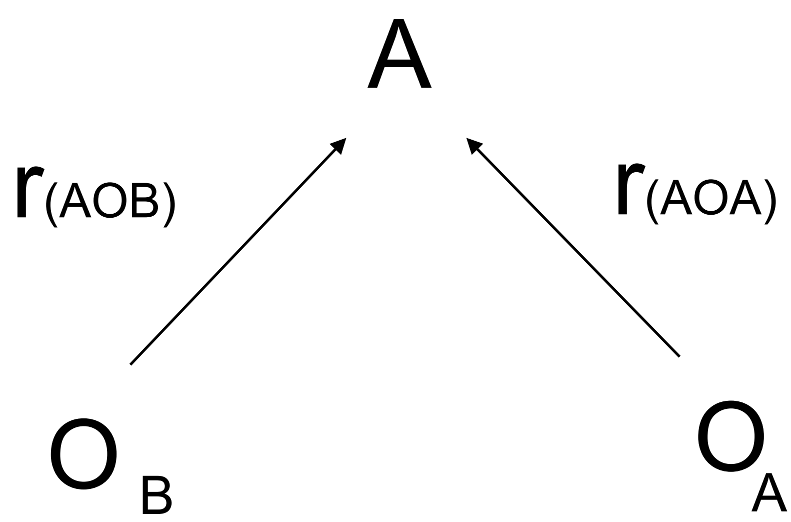
Compare hindcast skill with an observation

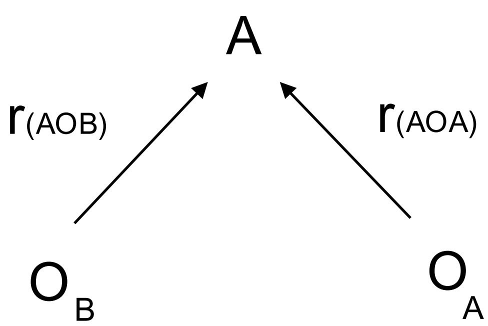


Reversing the question

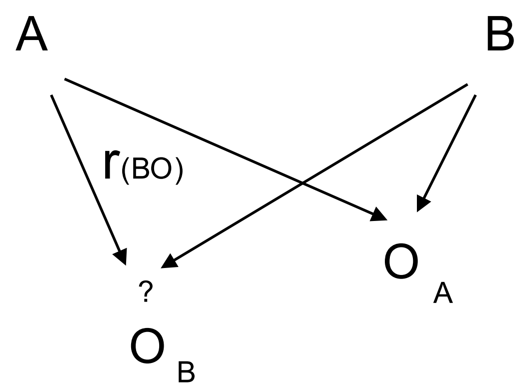
Which observation is better? A useful question?



Overview this presentation

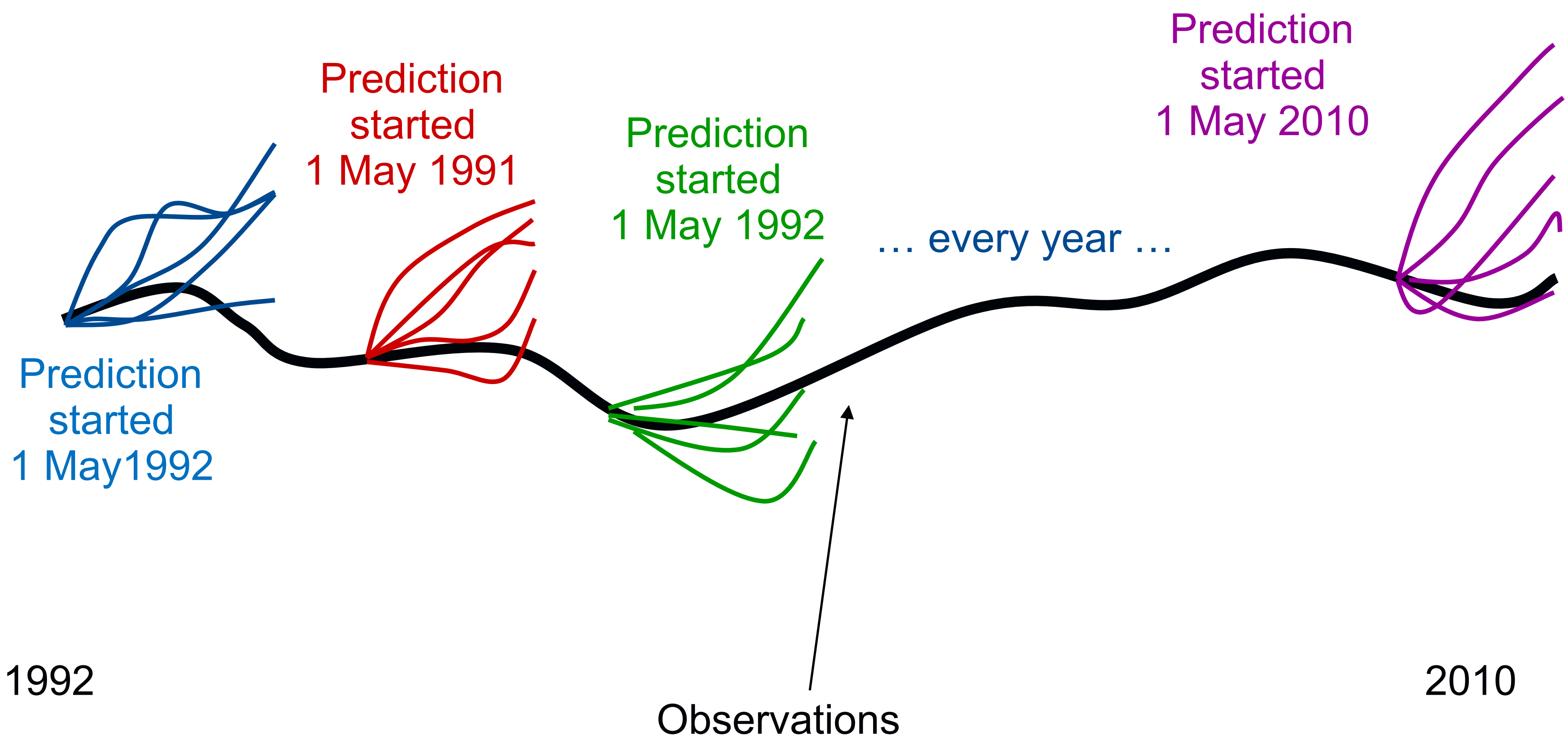


(a) Which observations has the smallest error



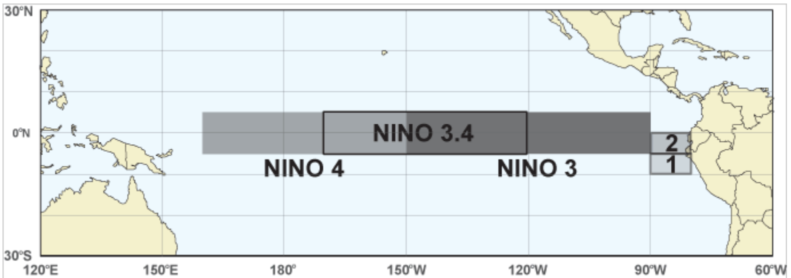
(b) How important is the observational uncertainty

Seasonal forecast skill



Seasonal forecast skill

Target: Global and Niño3.4 SST



Observations: 4 Sea-surface Temperature (SST) observations: ESA-CCI, HadISST, ERSST4, ERA-Interim

Prediction started 1 May1992

Prediction started 1 May 1991

Prediction started 1 May 1992

… every year …

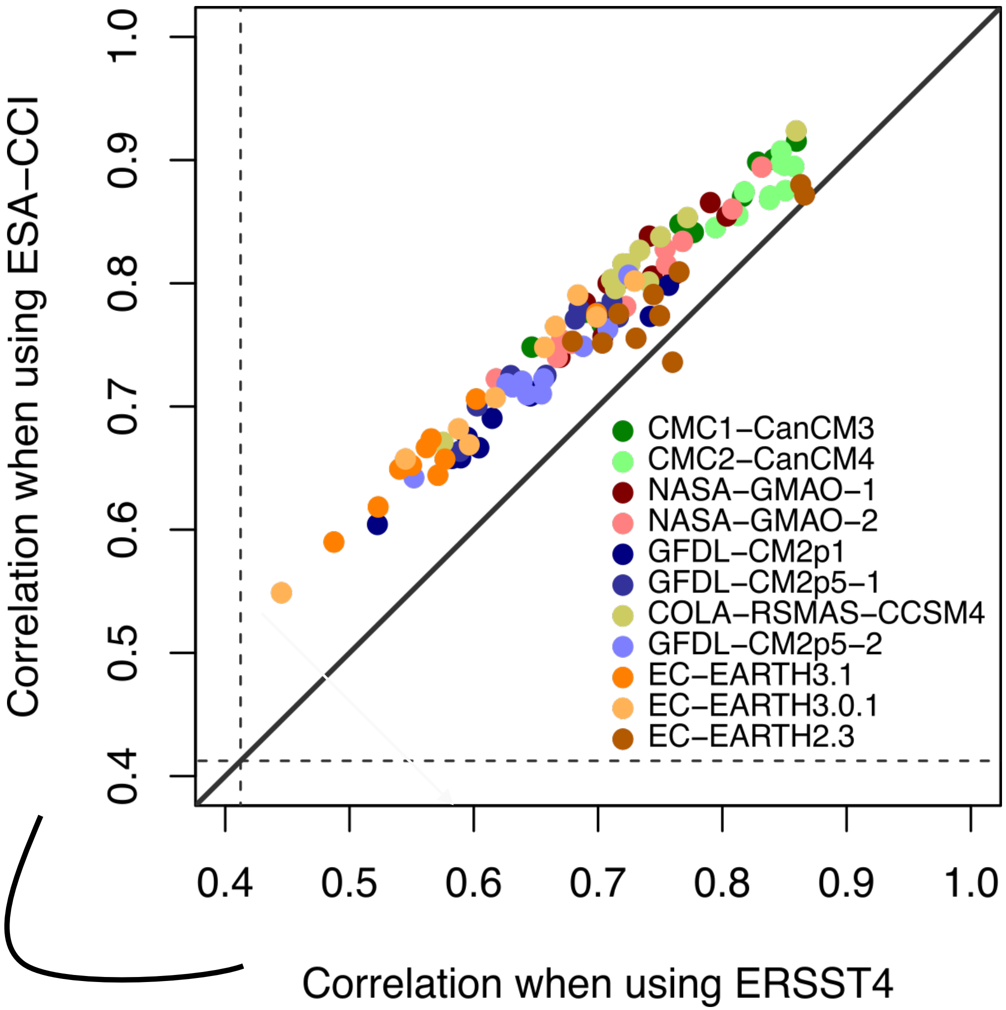
Prediction started 1 May 2010

Compute ensemble-mean and calculate anomaly correlation

Models: EC-Earth (3 versions), ECMWF S4, North American Multi-Model Ensemble (NMME, 7 models)
10 – member forecast each

CCI SST yields systematic higher correlation skill across many models

Independent from the models

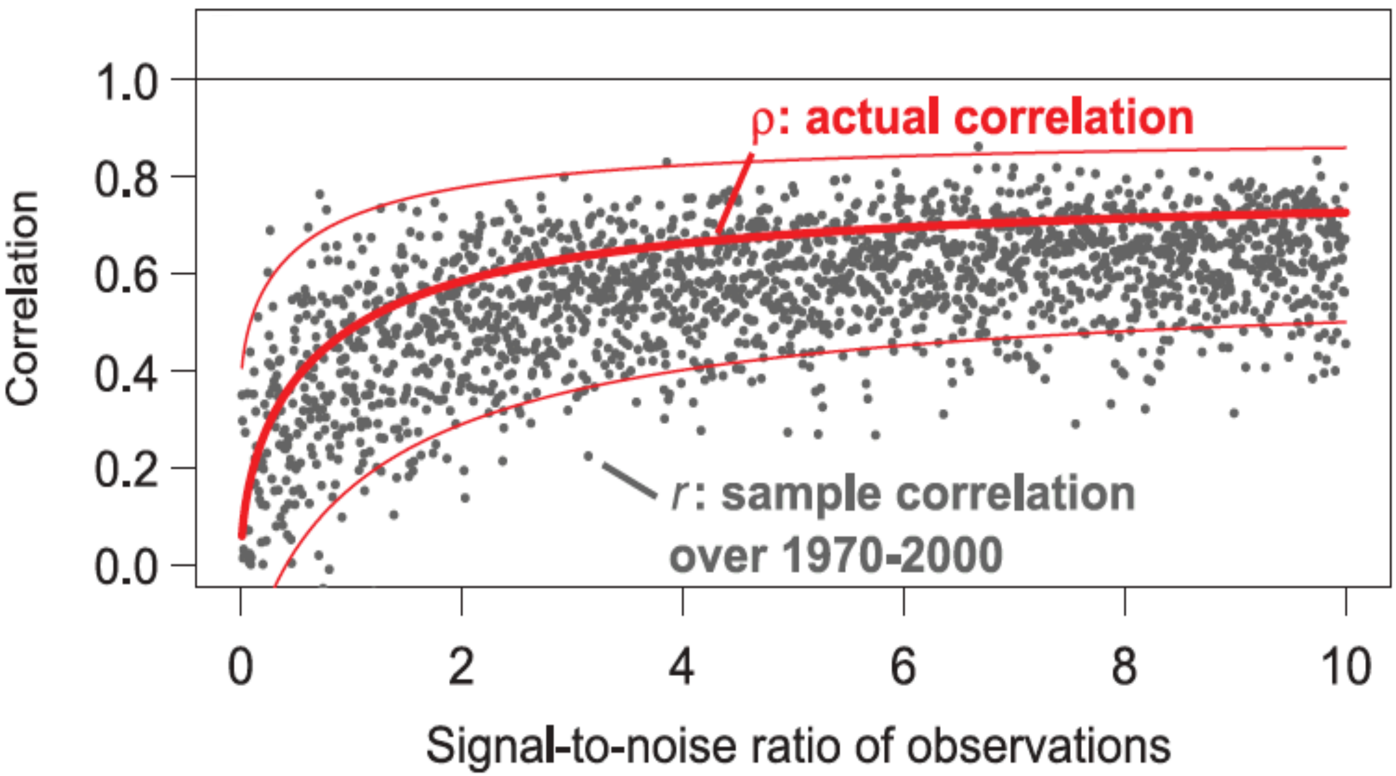


Fully independent datasets

Massonnet et al. (2016) Science

Effect observational uncertainty

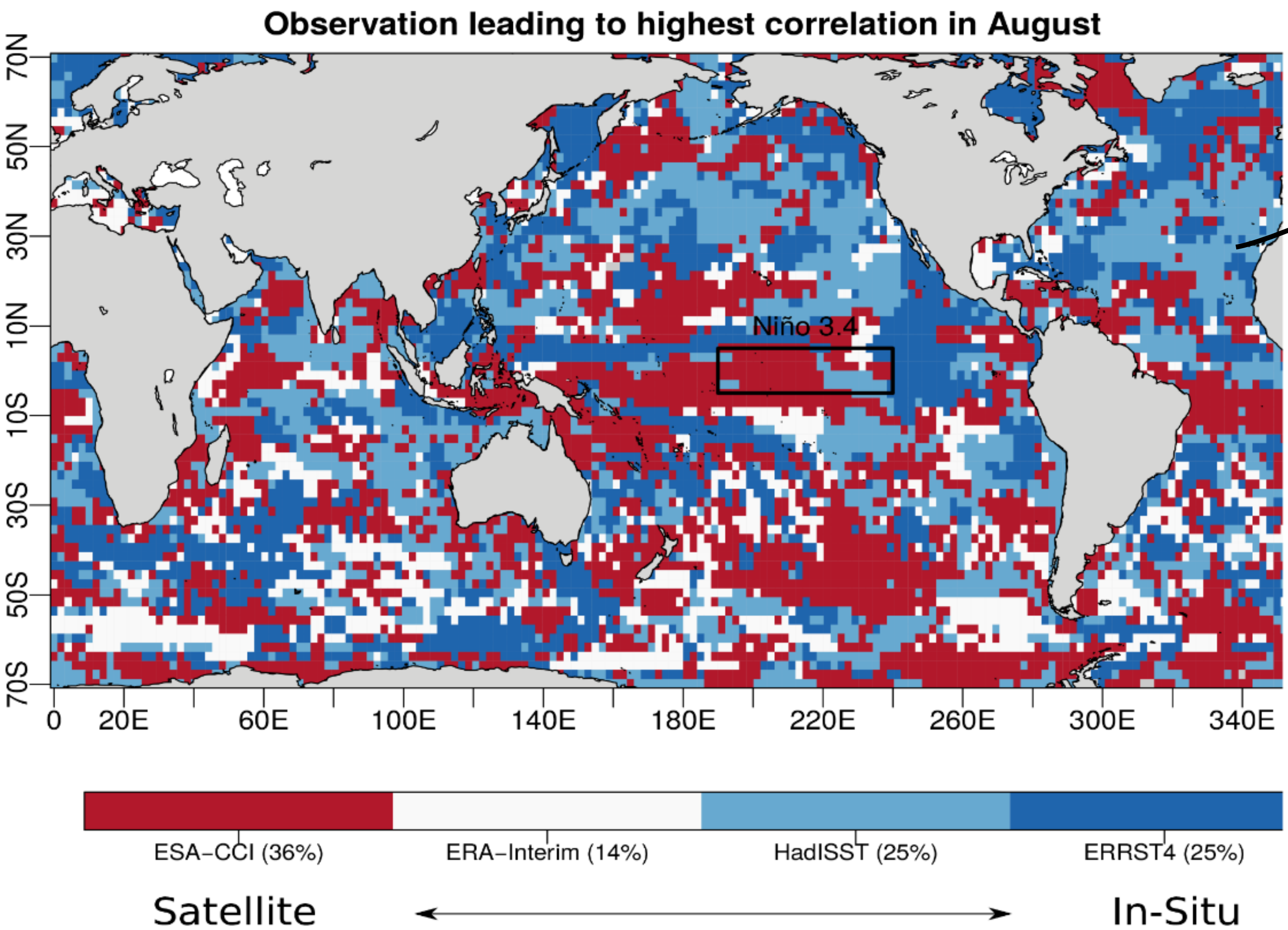
Correlation reduces with noise either co-variates: observational uncertainty reduces forecast skill



Massonnet et al. (2016) Science

Reversing verification question

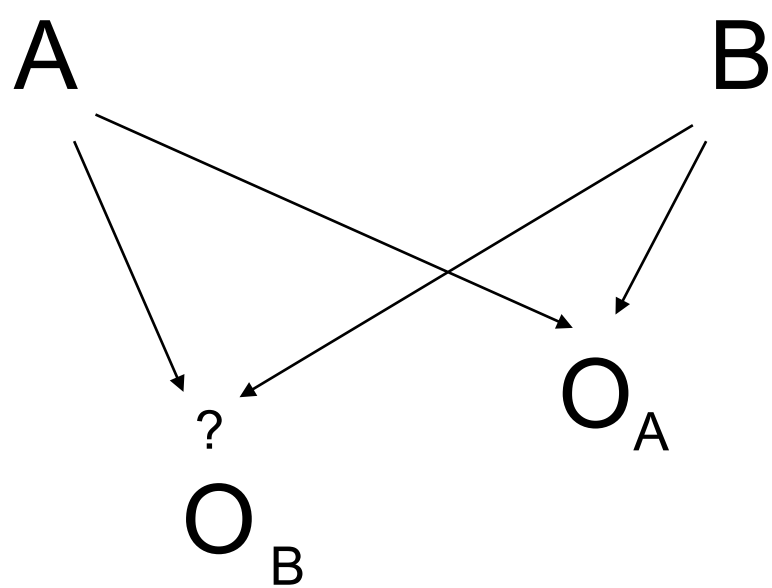
Choice of observation may differ on the location, overall CCI best



Shipping routes?

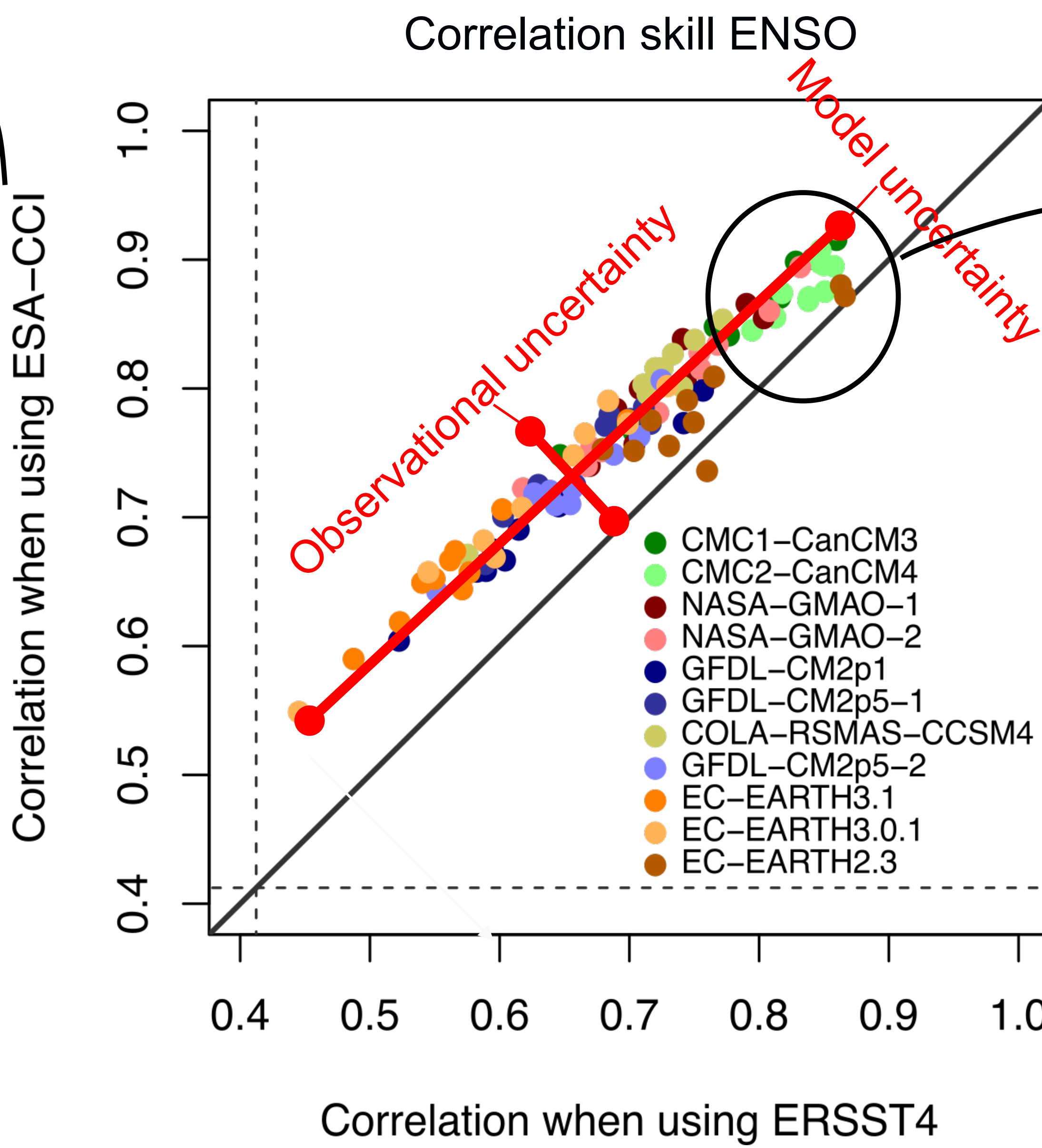
Massonnet et al. (2016) Science

How important is the observational uncertainty?



Acknowledging joint uncertainty

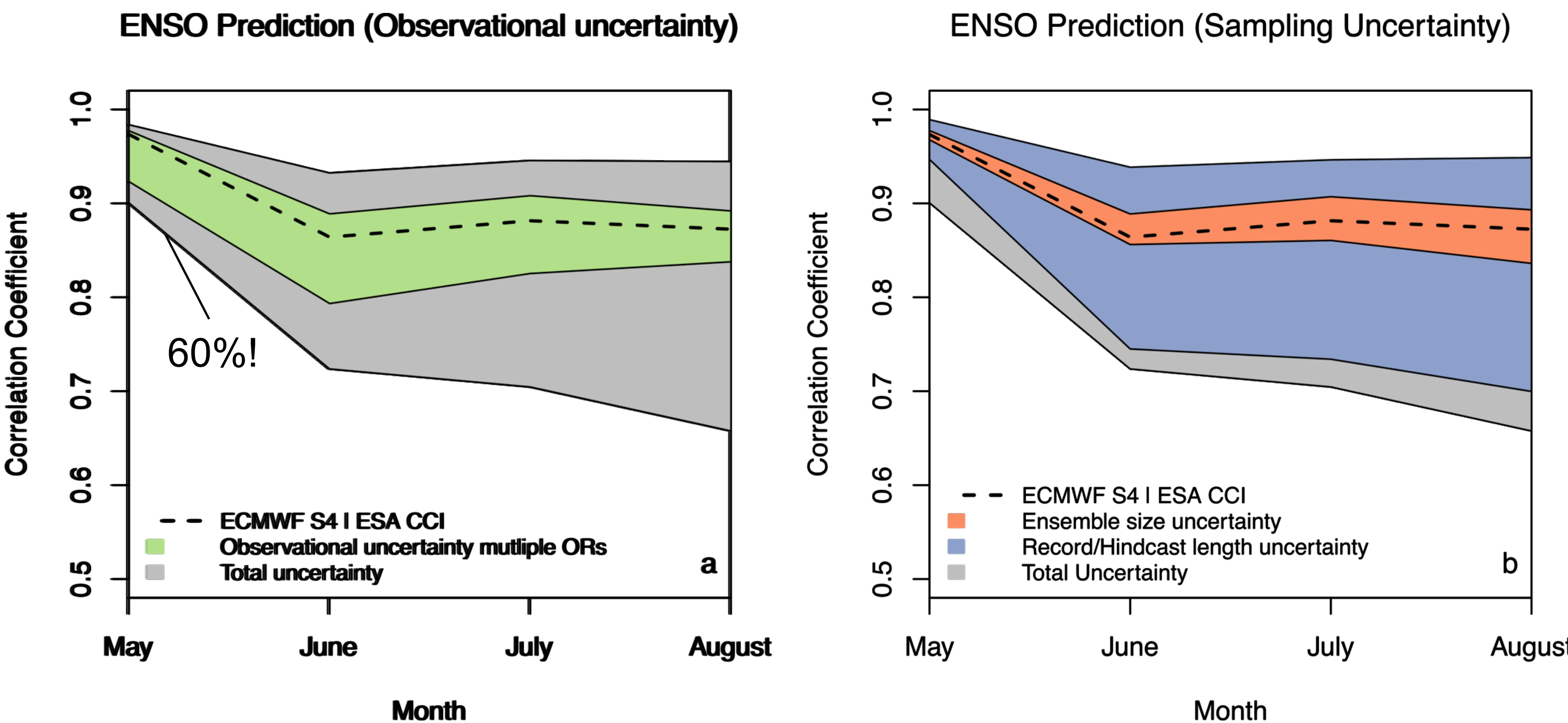
Independent from the models



How important for individual system?

Decomposition of uncertainties

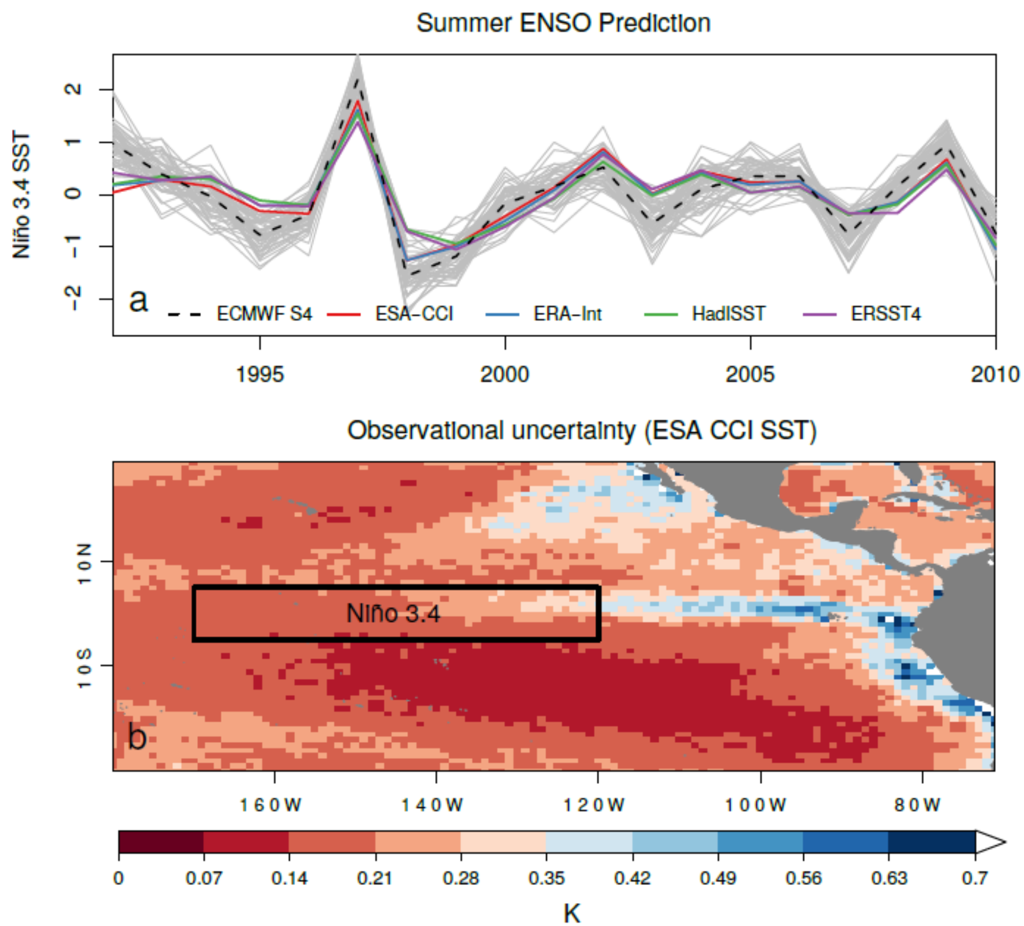
Comparison to sample uncertainties: observational uncertainty is an important source of verification uncertainty for ENSO



Bellprat et al. (2017) Remote Sensing of the Environment

Observational uncertainty CCI

Model evaluation often requires spatial and temporal averaging, requires the consideration of error correlation scales



Monthly
Niño3.4

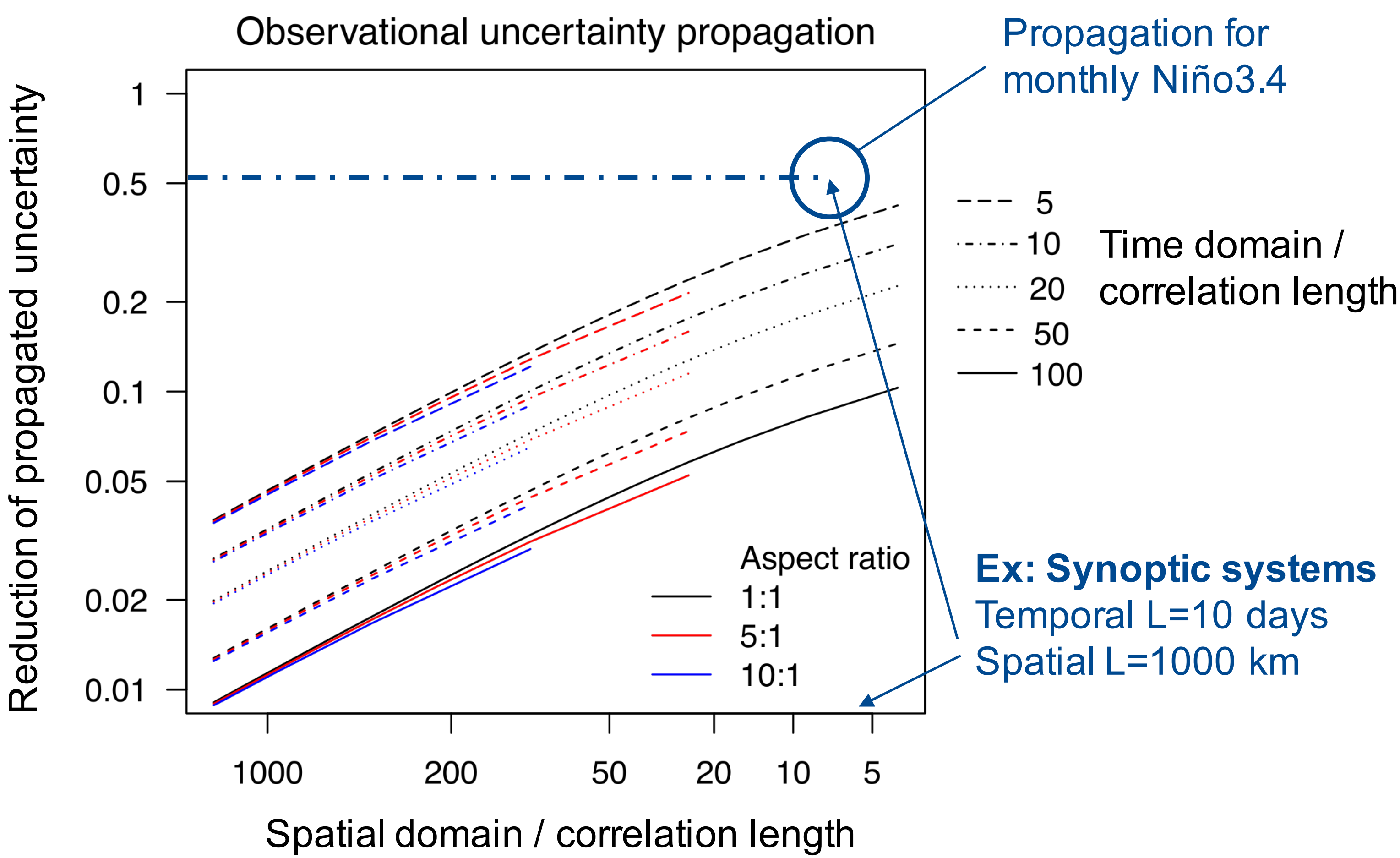
Uncorrelated uncertainty reduces by $1/\sqrt{N}$ but errors are not uncorrelated!

Daily, 4 km

Bellprat et al. (2017) Remote Sensing of the Environment

A “look-up” propagation approach

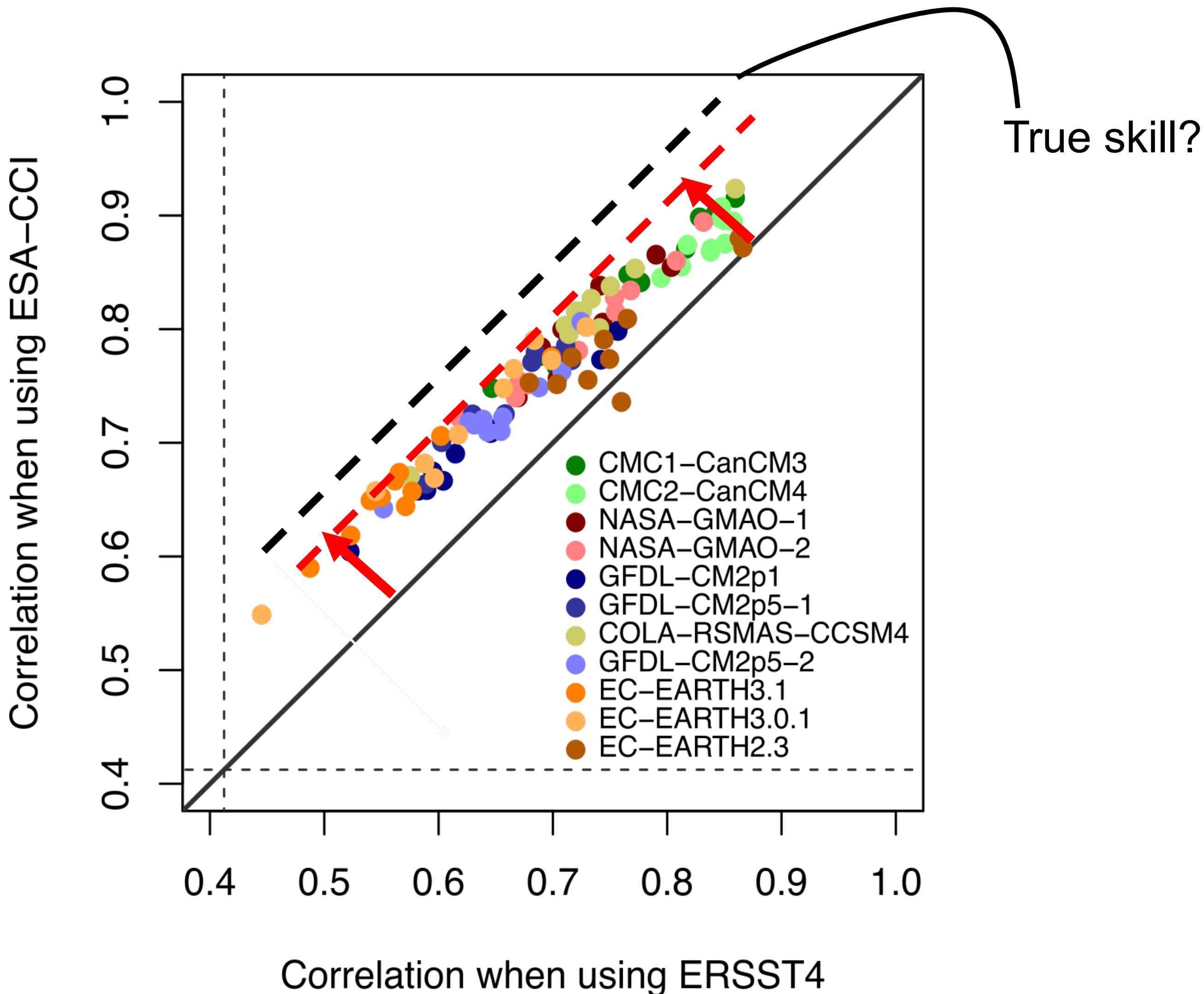
Use of error correlation scales: analytical solution that allows to look-up propagation factors



Bellprat et al. (2017) Remote Sensing of the Environment

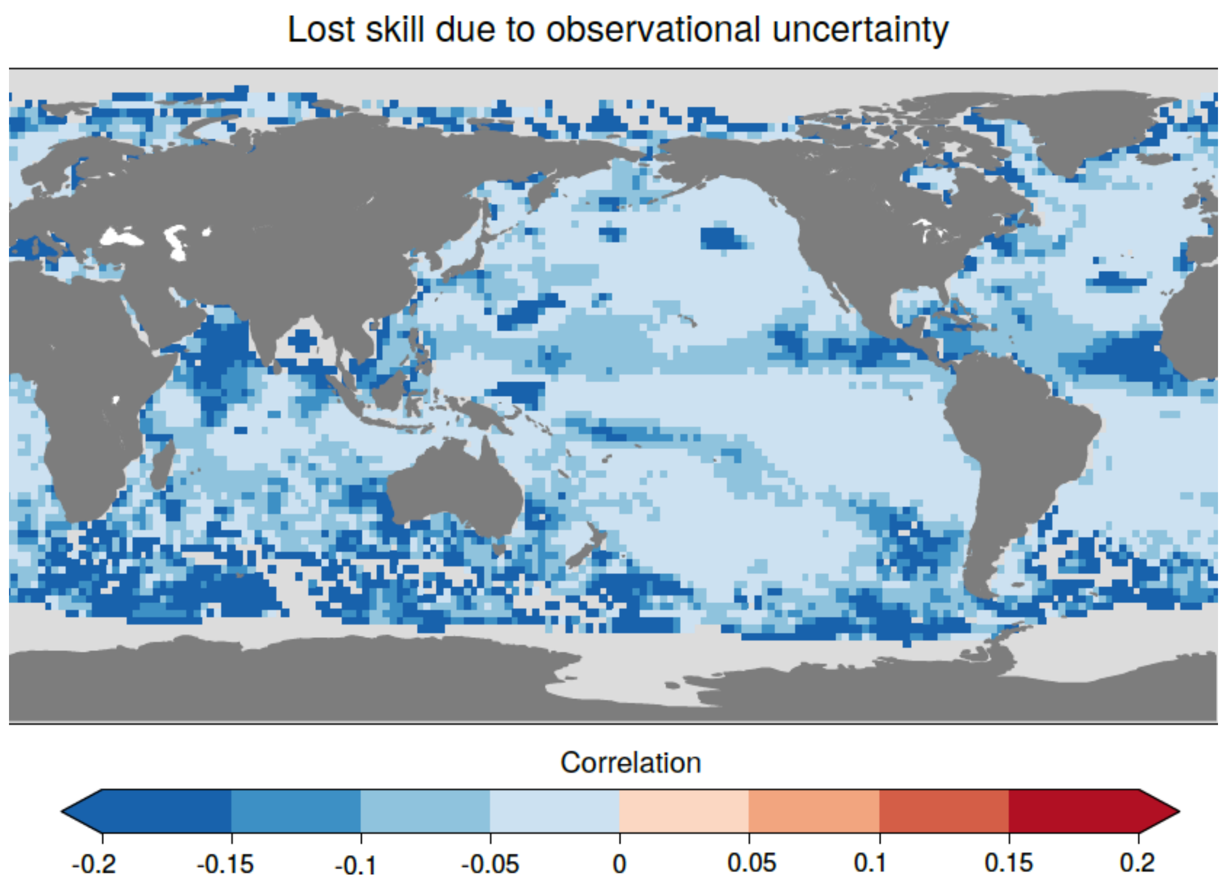
What is the “true” skill ?

True climate predictions skill is systematically underestimated due to uncertainties in the observations



Underestimation of “true” skill

Seasonal SST forecast skill is underestimated up to 0.2 correlation



Correction for attenuation of correlation coefficients (Spearman, 1904)

A joint uncertainty perspective

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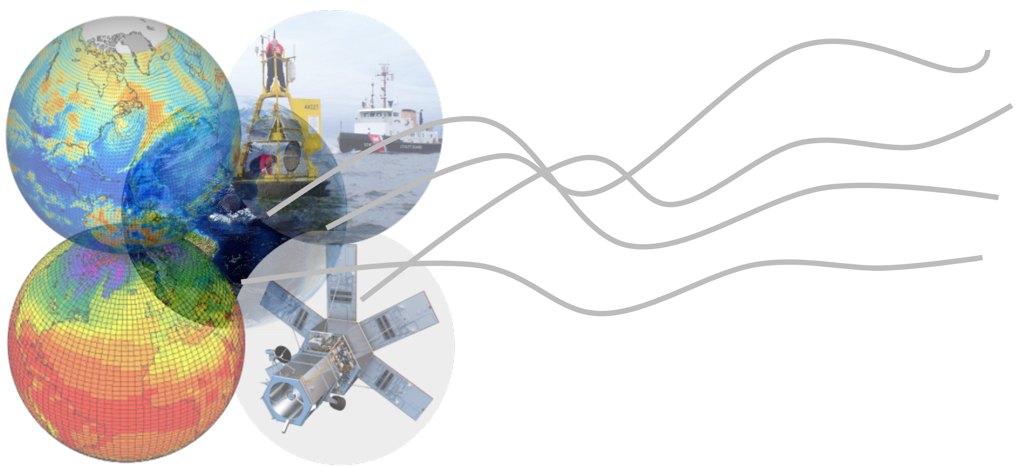
Models and observations are both approximations of the truth and uncertainty in both sources can be important.

Models can be valuable in assessing observational quality and thus guide to a more objective dataset selection

Observational uncertainty needs to be propagated for climate model evaluation and metrics that allow to account for uncertainty need to be defined.



Outlook: CMUG3

Climate Modelling User Group (CMUG) is building a new proposal for the next phase of the ESA Climate Change Initiative (CCI+).

Evaluation, Emergent Constraints, Initialization, Re-analysis, Process understanding, Machine Learning, Impacts

WP4: Joint uncertainty assessment of observations and models:

- Uncertainty propagation to model scales for CCI (+) variables
- Defining deterministic and probabilistic measures that account for observational uncertainties
- Systematic comparison between observational and model uncertainties (internal variability, structural uncertainty)

Thank you!

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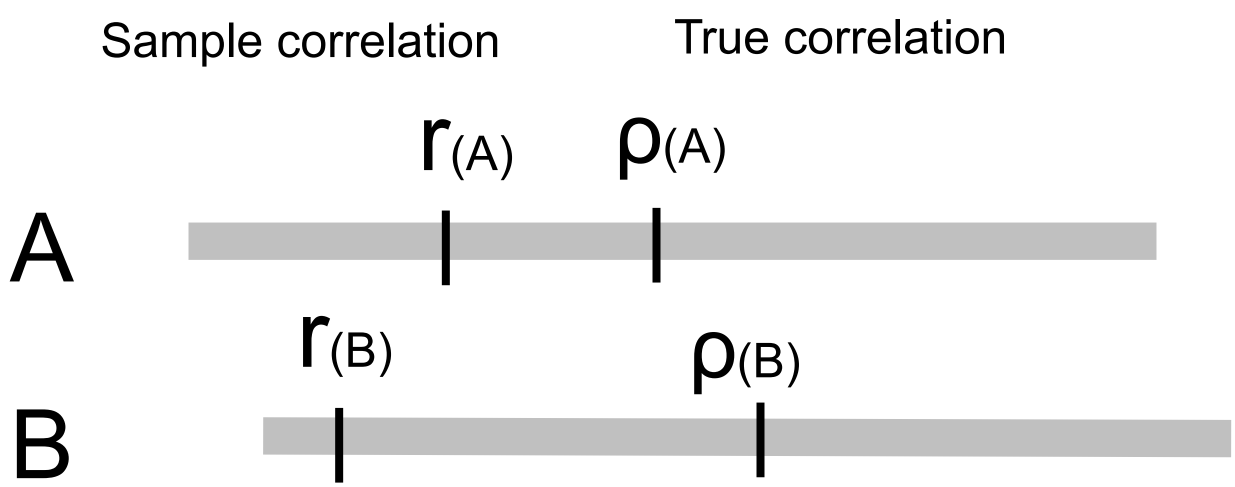
Massonnet, F., Bellprat, O., Guemas, V., Doblas-Reyes, F. J., (2016). Using climate models to estimate the quality of global observational data sets, *Science (AAAS)*

Bellprat, O., Massonnet, F., Siegert, S., Guemas, V., Doblas-Reyes, F. J. (2017). Uncertainty propagation of observational references to climate model scales, *Remote Sensing of the Environment (RSE)*, *accepted*

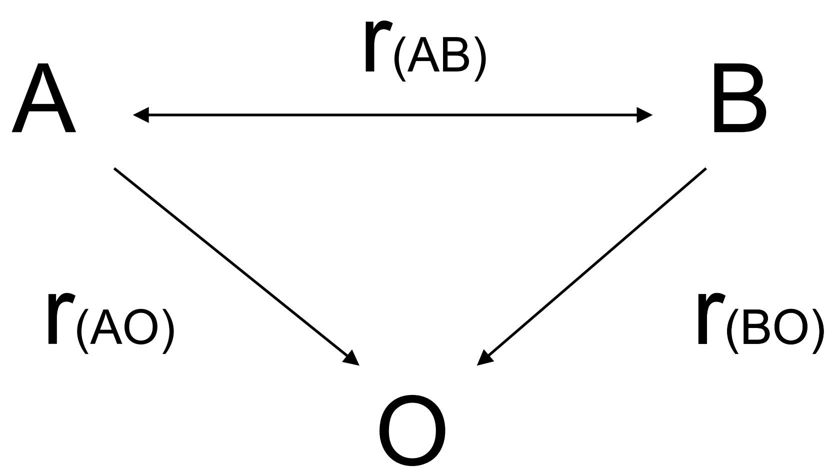
Extra Slides

Detecting statistical differences

Are the differences in performance of models or observations significant $r_{(CCI)} > r_{(ERSST)}$?



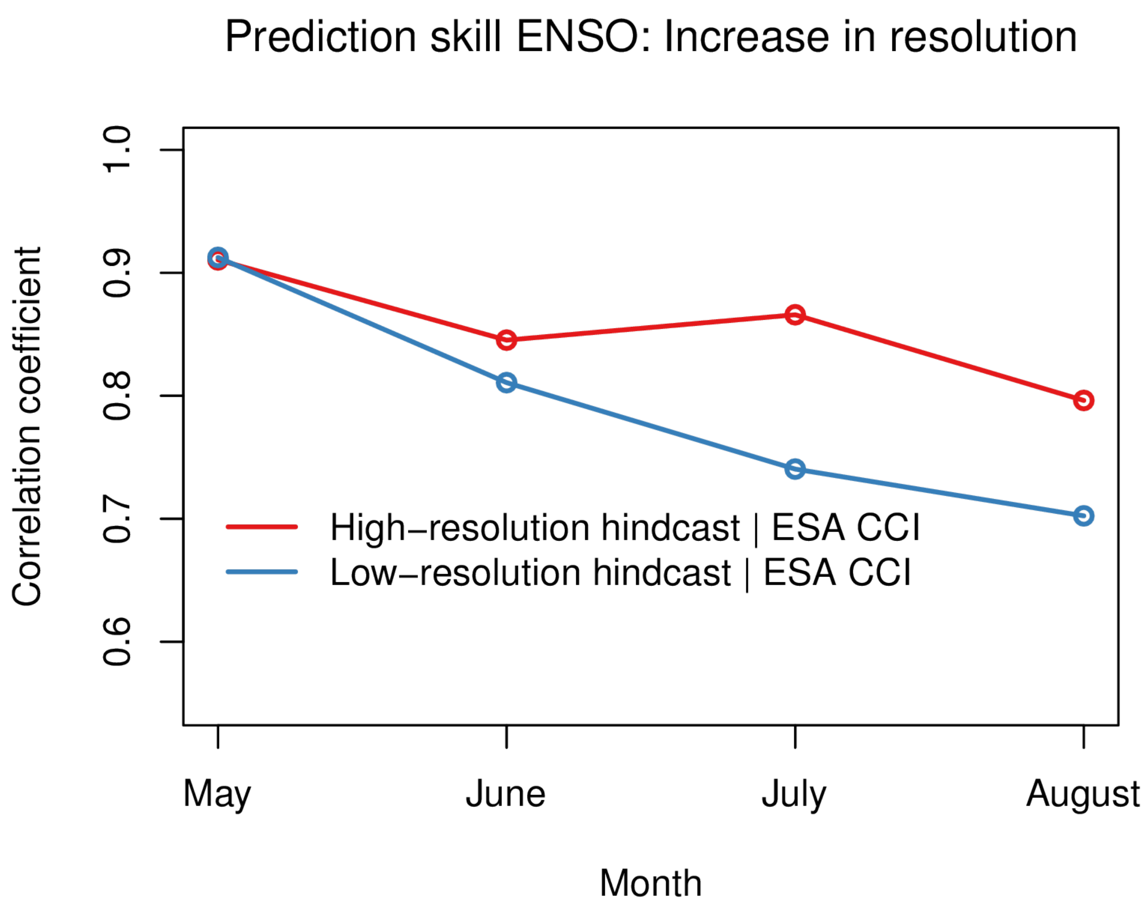
Models and observations are statistically dependent!



Fisher-test (common test in community) assumes independence while newer tests (Steiger, 1980, Zou, 2007) don't.

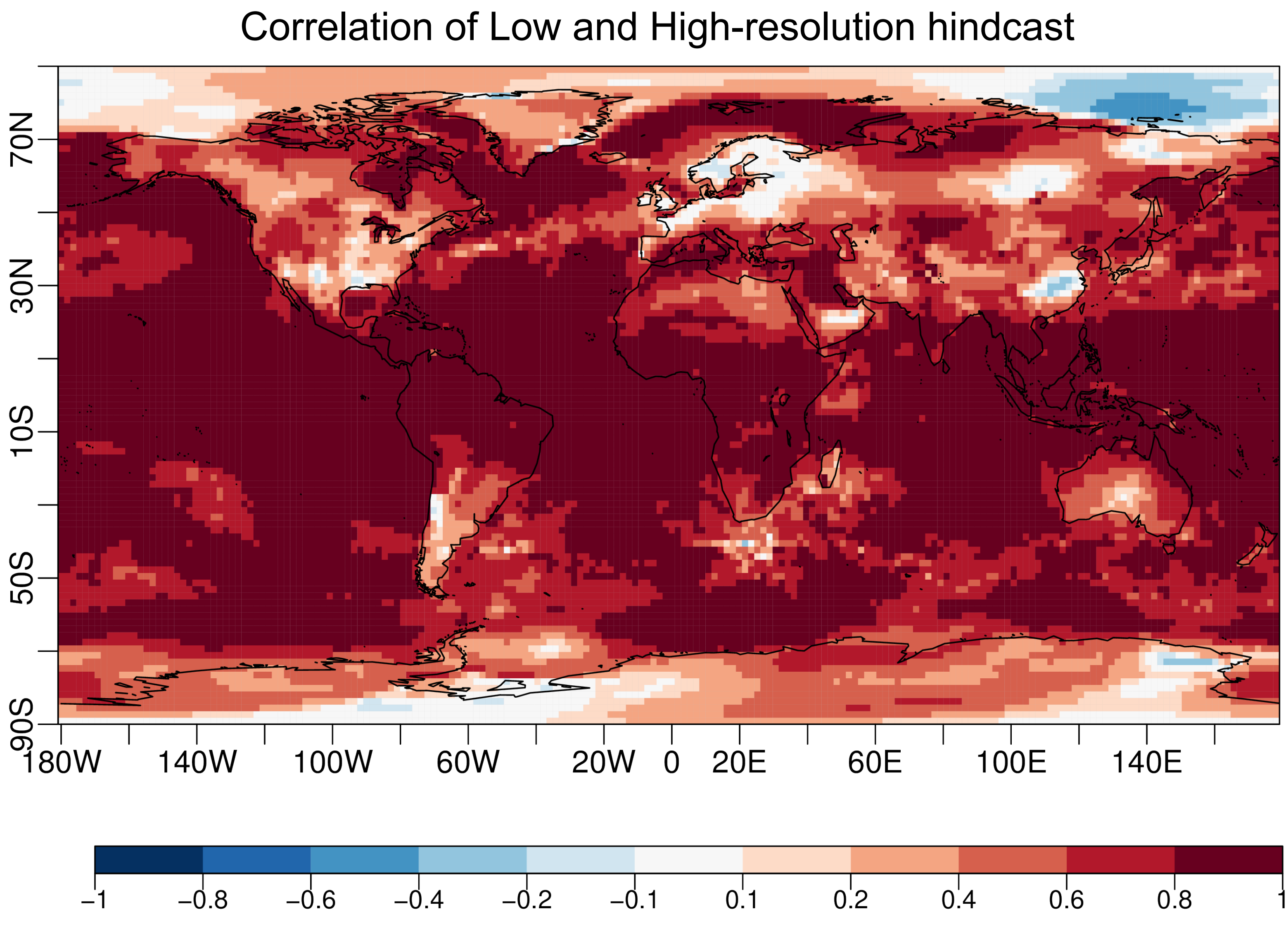
Example ENSO and resolution

High-resolution hindcasts improves El Niño Southern Oscillation (ENSO) predictions, but change not significant at 5% (Fisher-test)



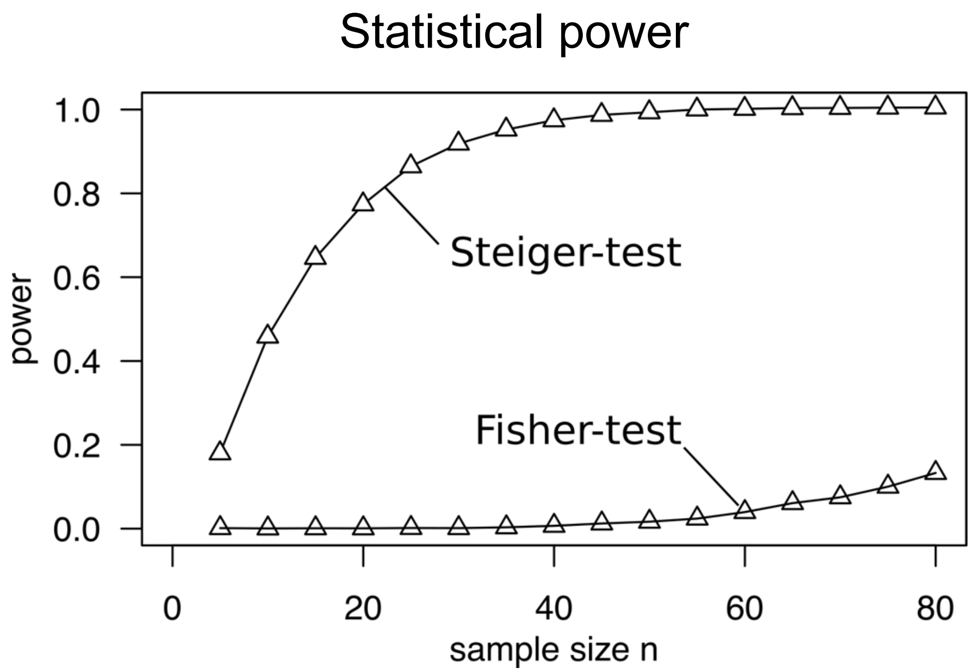
Bellprat et al. (2015) Tech. Rep. BSC 002

Model dependence



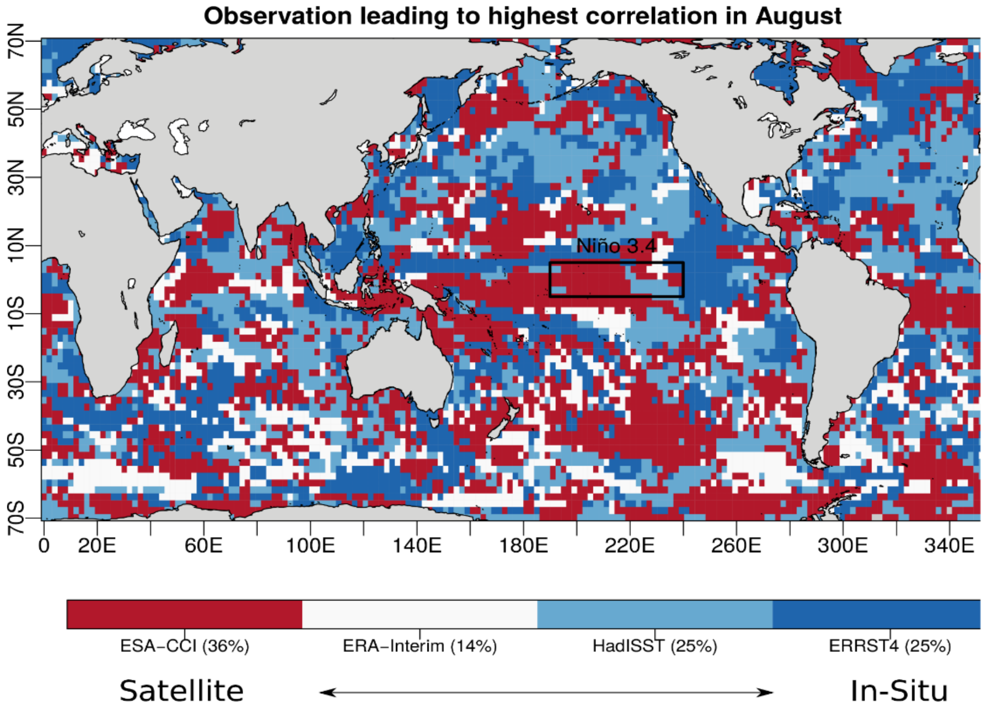
Statistical power dependent tests

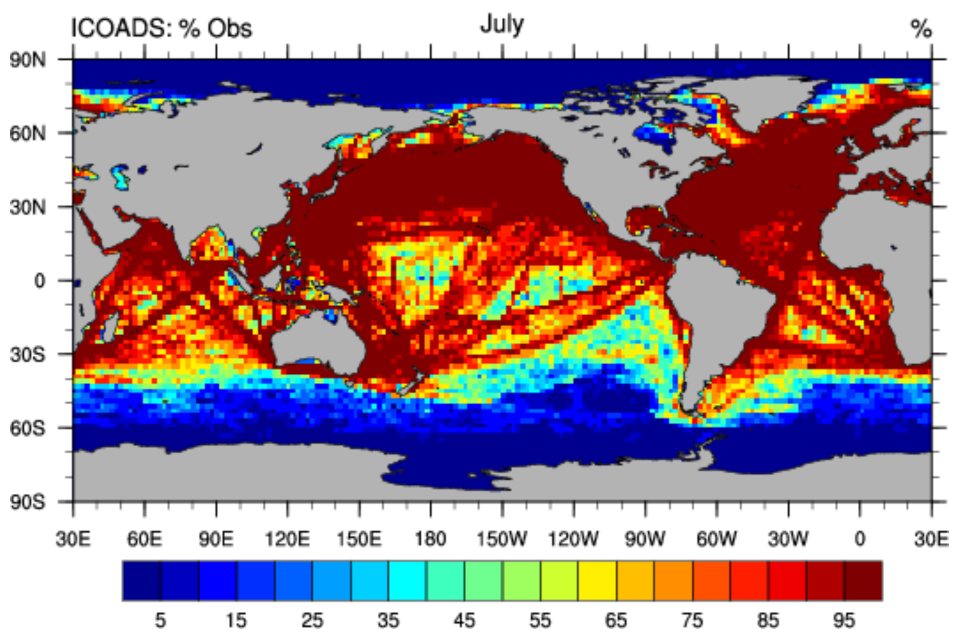
Power to detect a difference between increases dramatically. Improvement now statistical significant at 1% level.



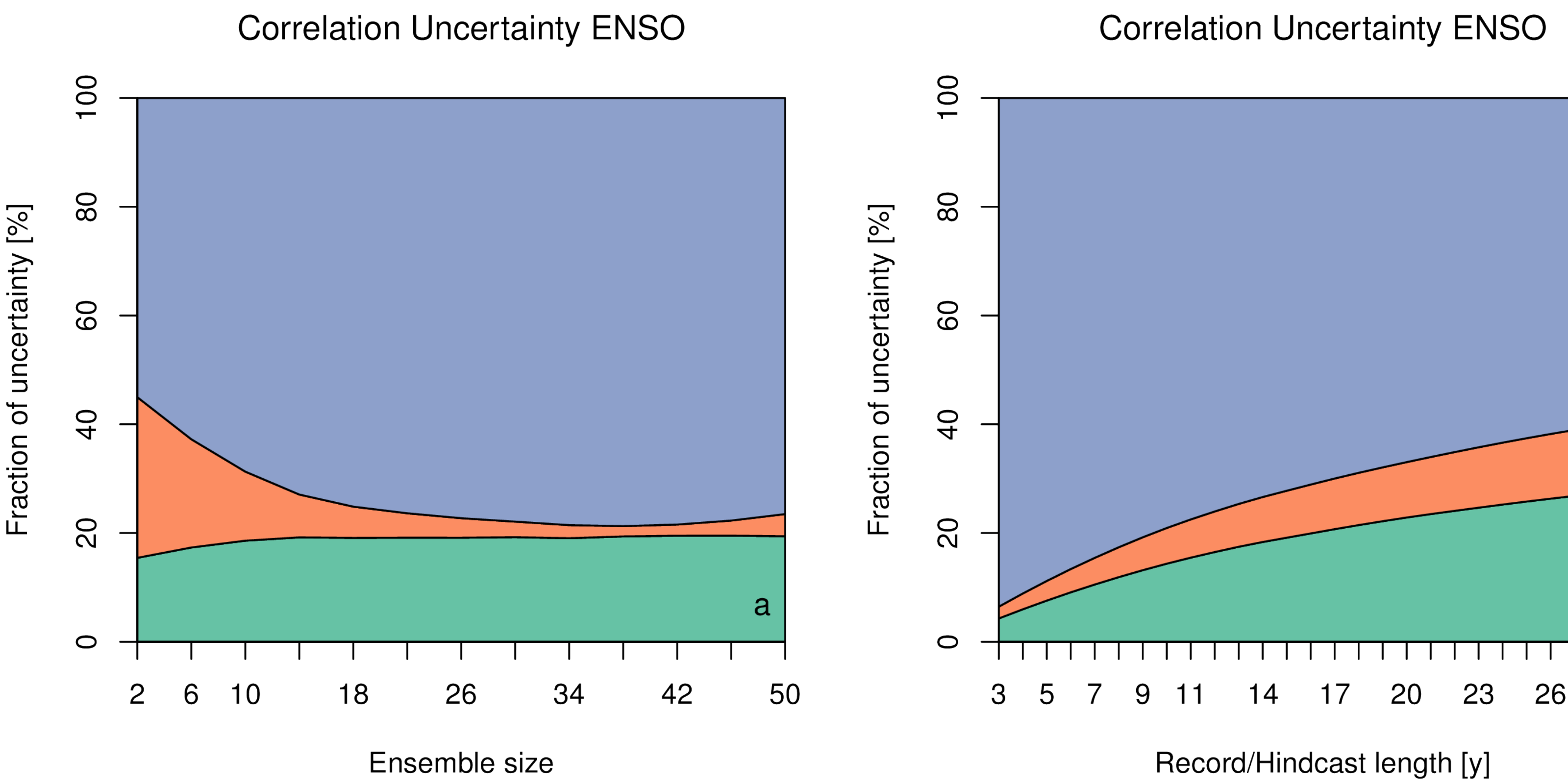
In medicinal science only studies with power > 80% are accepted, a guideline for forecasting?

Siegert et al. (2017) Monthly Weather Review


Observation leading to highest correlation in August
70N
50N
30N
10N
10S
30S
50S
70S
0
20E
60E
100E
140E
180E
220E
260E
300E
340E
Niño 3.4
ESA−CCI (36%)
ERA−Interim (14%)
HadISST (25%)
ERRST4 (25%)
Satellite
In-Situ

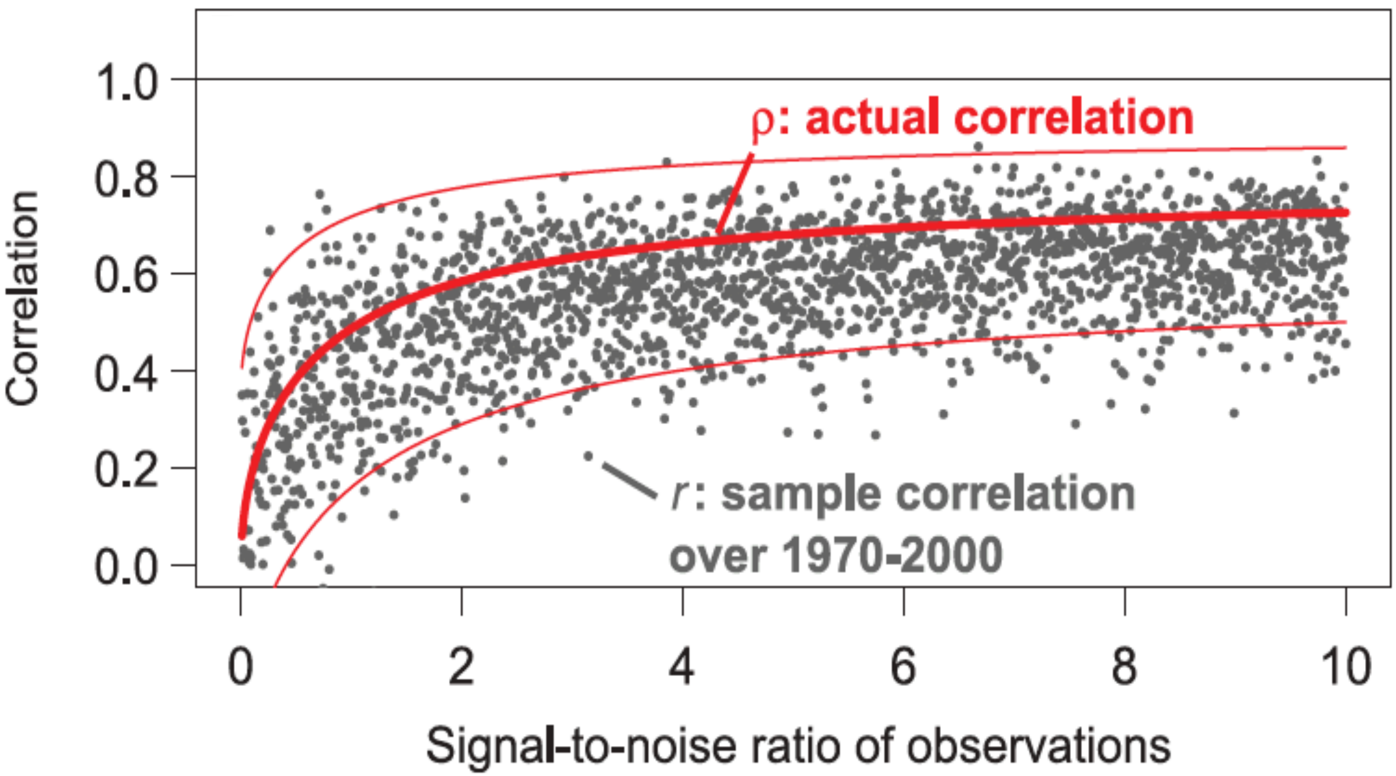

ICOADS: % Obs
July
%
90N
60N
30N
0
30S
60S
90S
30E
60E
90E
120E
150E
180
150W
120W
90W
60W
30W
0
30E
5
15
25
35
45
55
65
75
85
95

Sensitivity to sample



Effect observational uncertainty

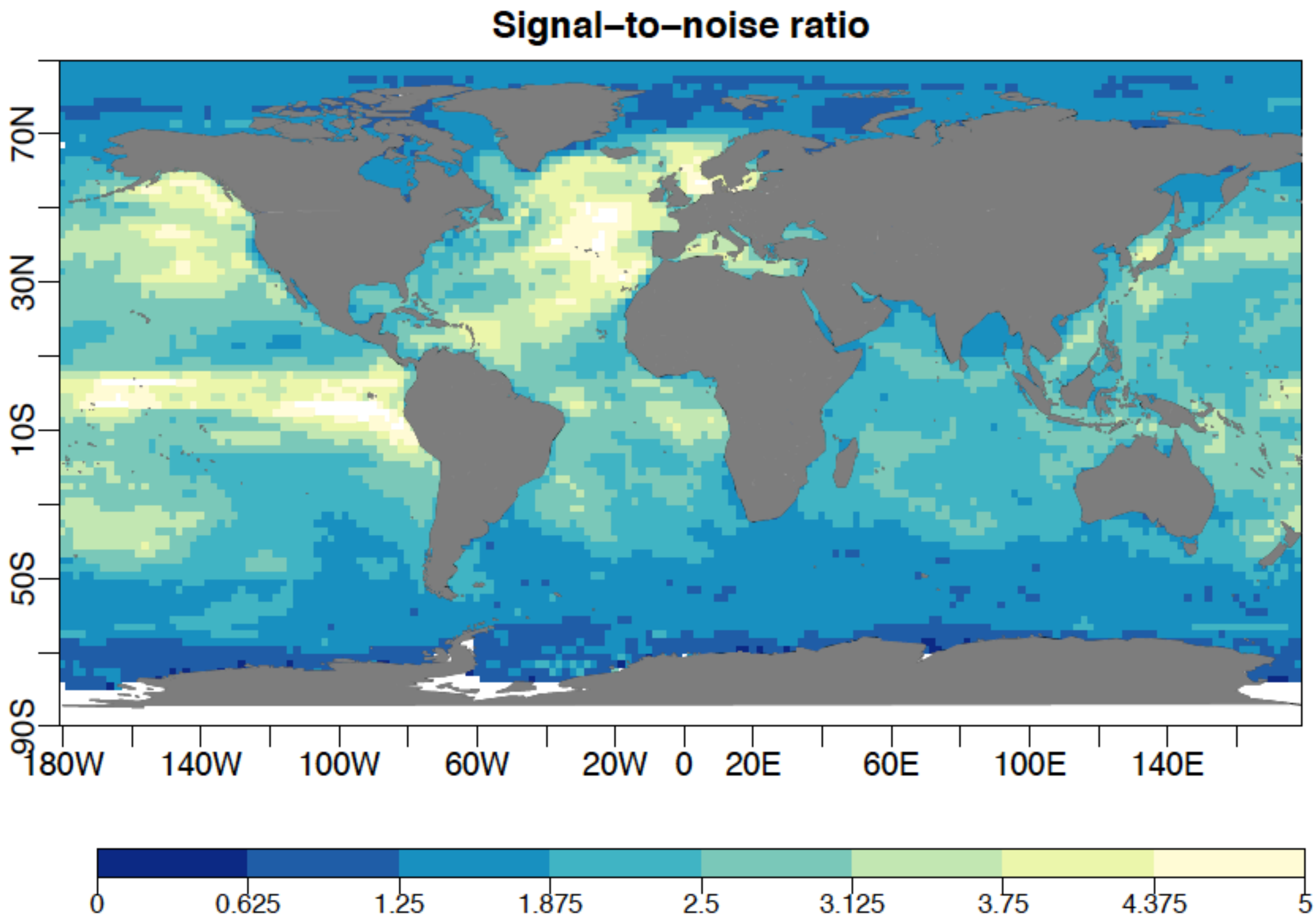
Correlation reduces with noise either co-variates: observational uncertainty reduces forecast skill



Massonnet et al. (2016) Science

Signal-to-noise ratio SSTs

Signal (inter-annual variability) versus observational uncertainty (noise)



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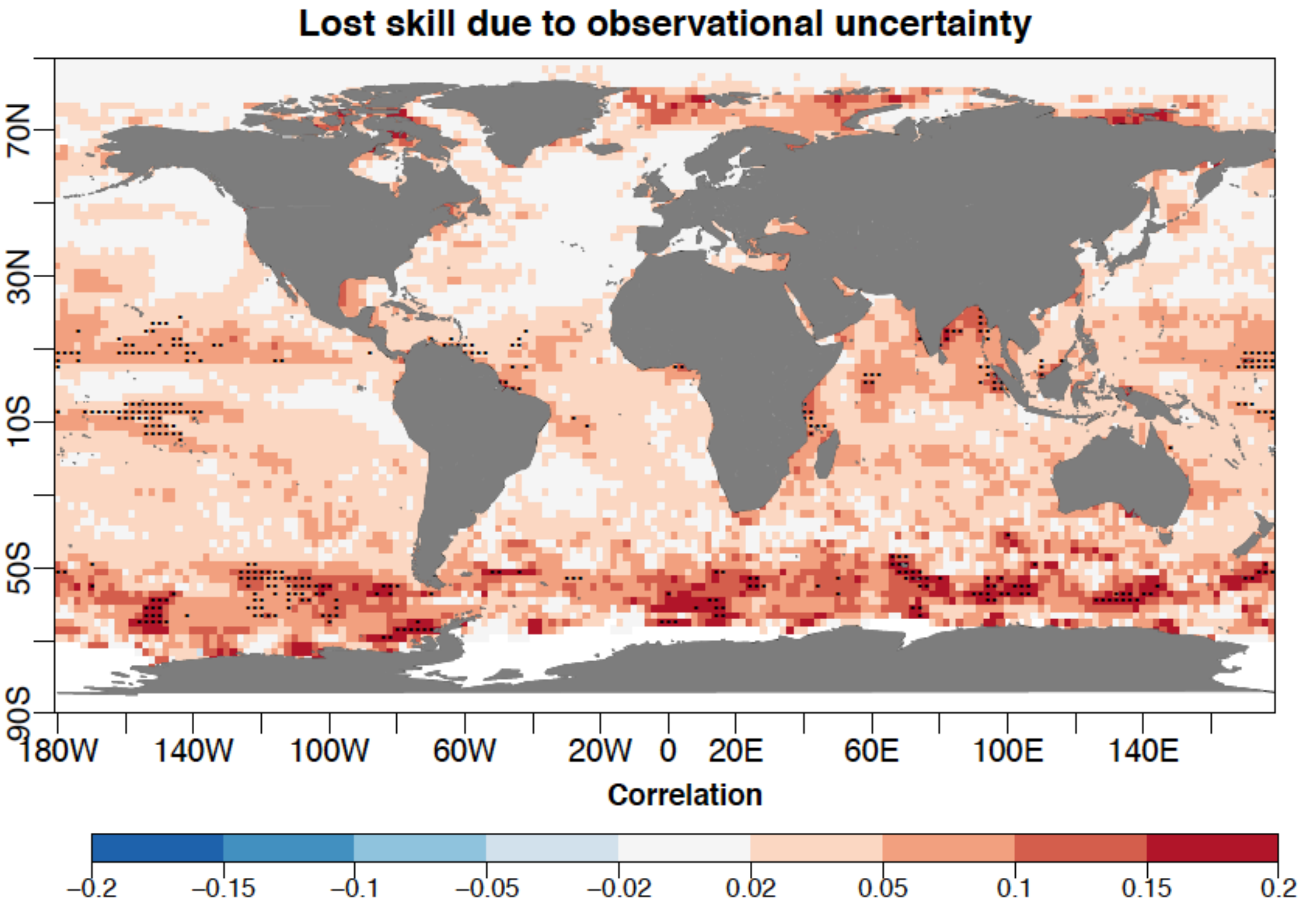
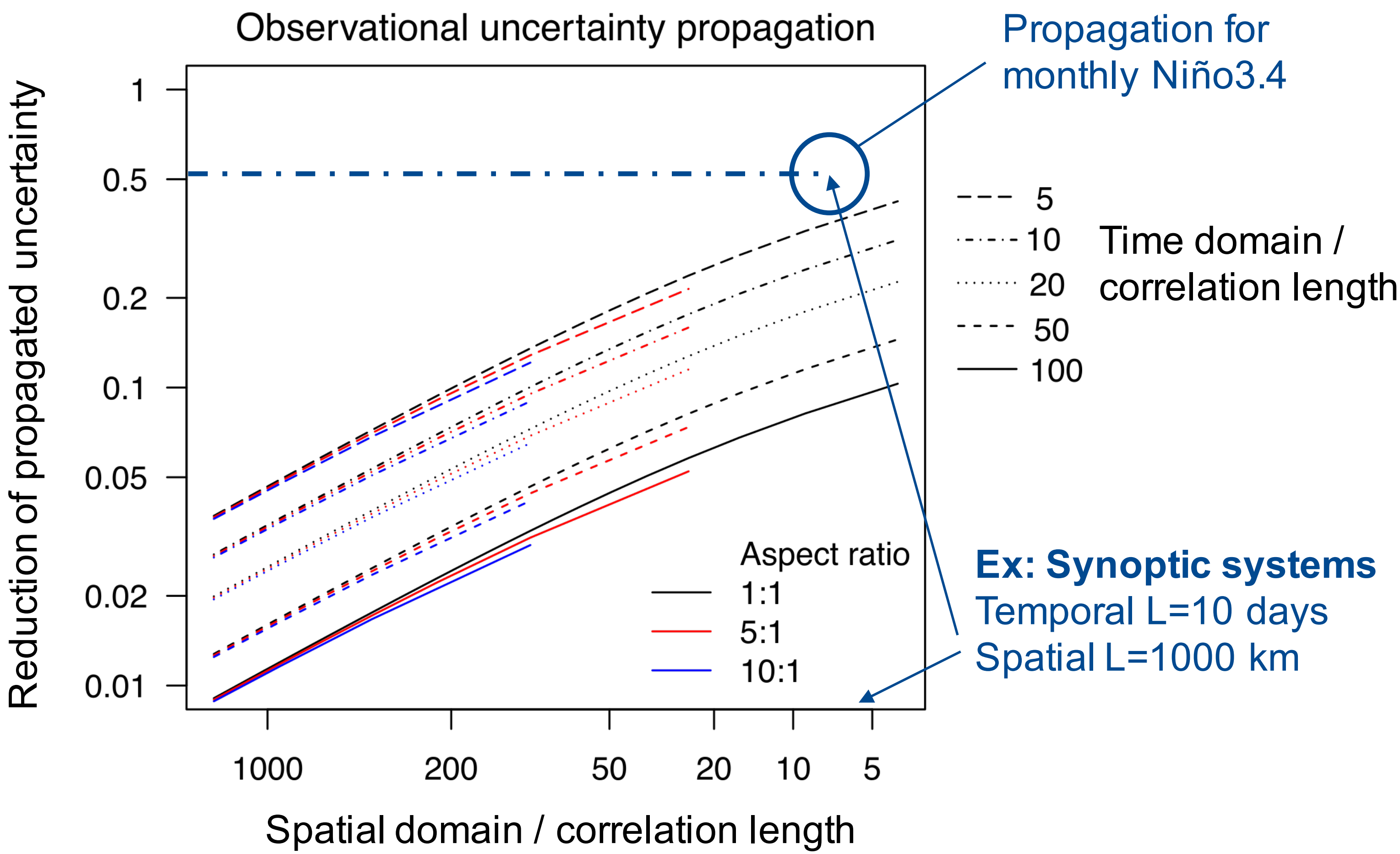


A “look-up” propagation figure

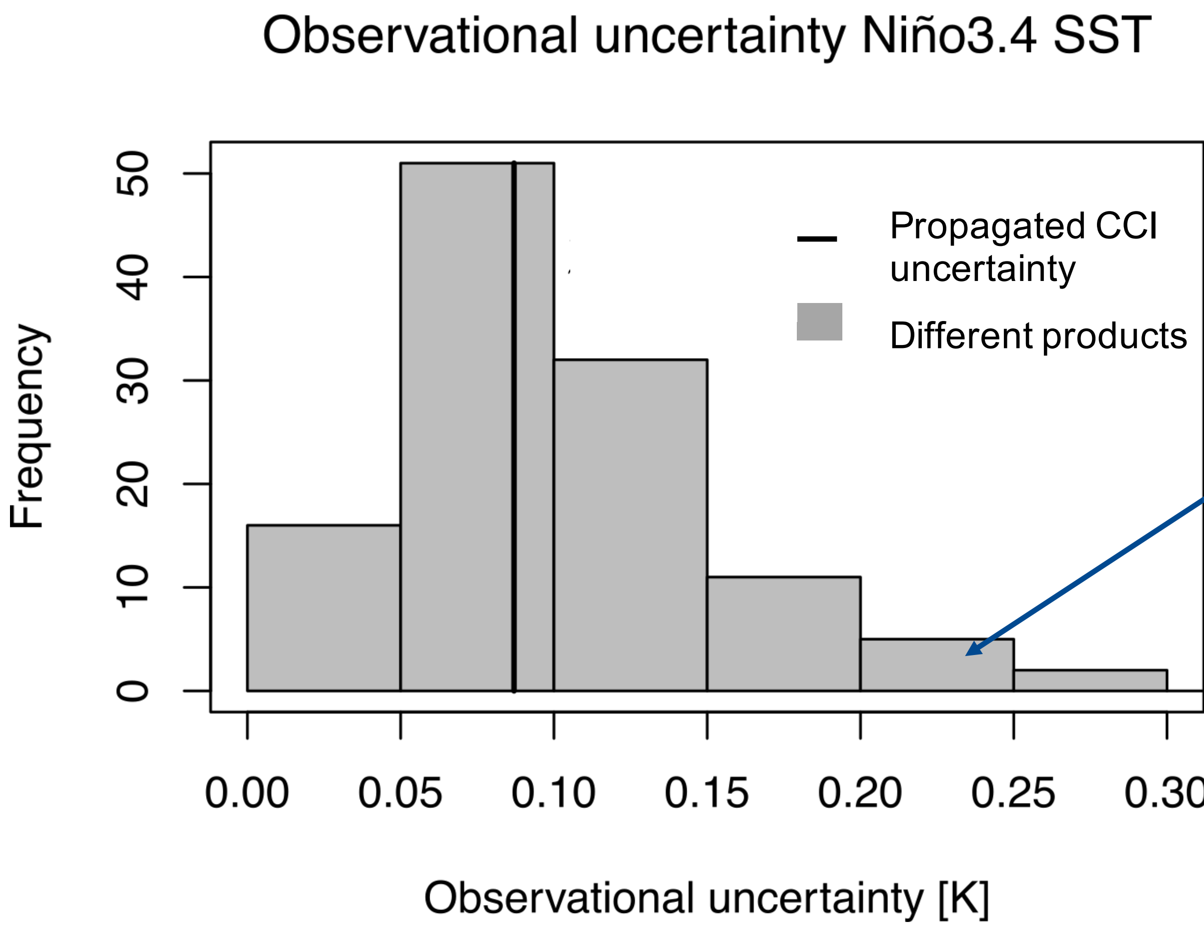
Use of error correlation scales: analytical solution that allows to look-up propagation factors



Bellprat et al. (2017) *RSE (in review)*

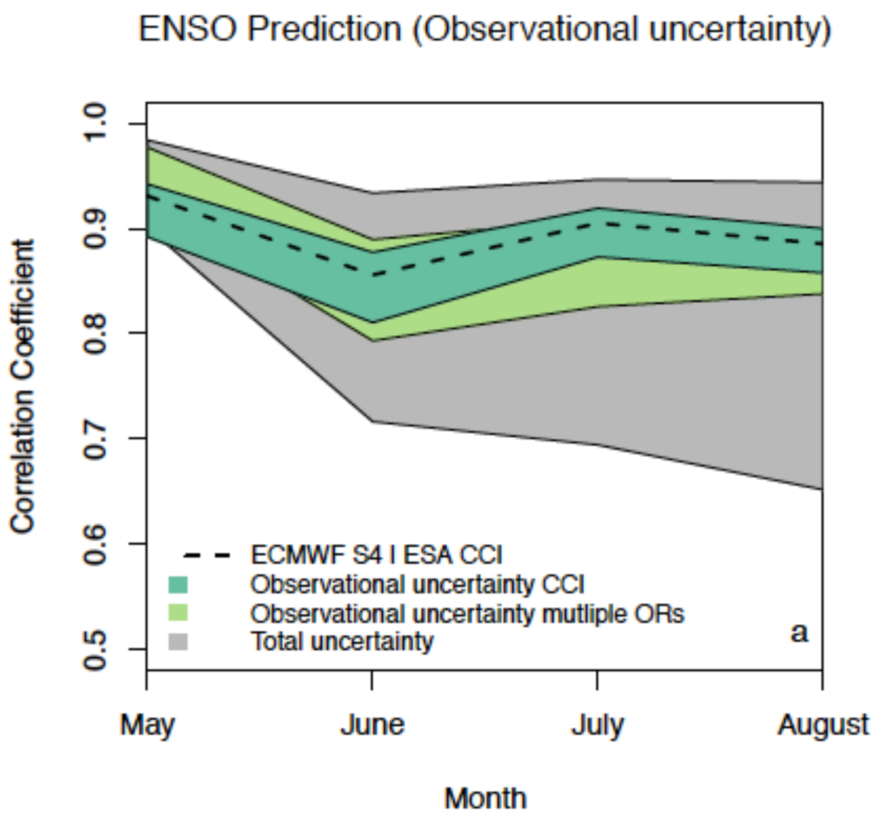
Comparison to multi-observations

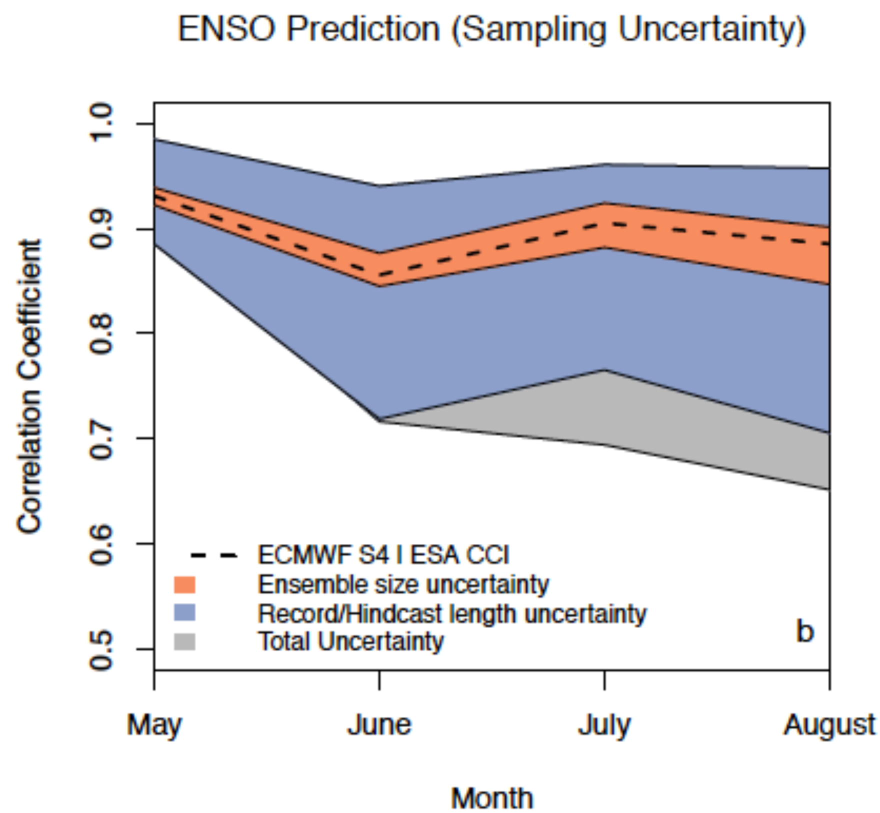
Propagation assuming synoptic scales (1000 km, 10 days) of weather systems agrees well with deviations between existing products



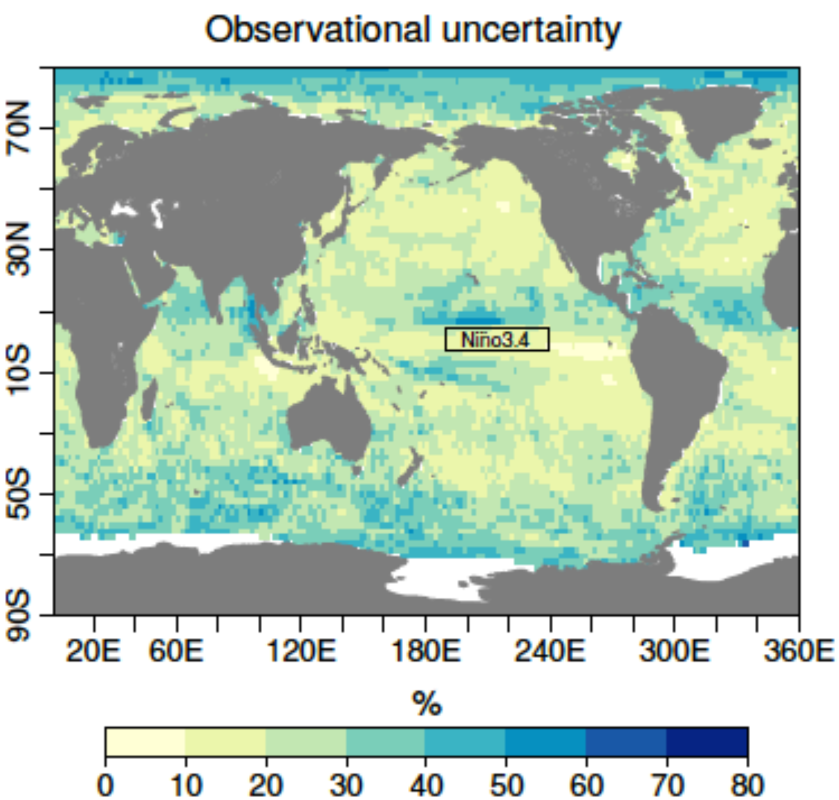
Assumes all observations are equally “likely”

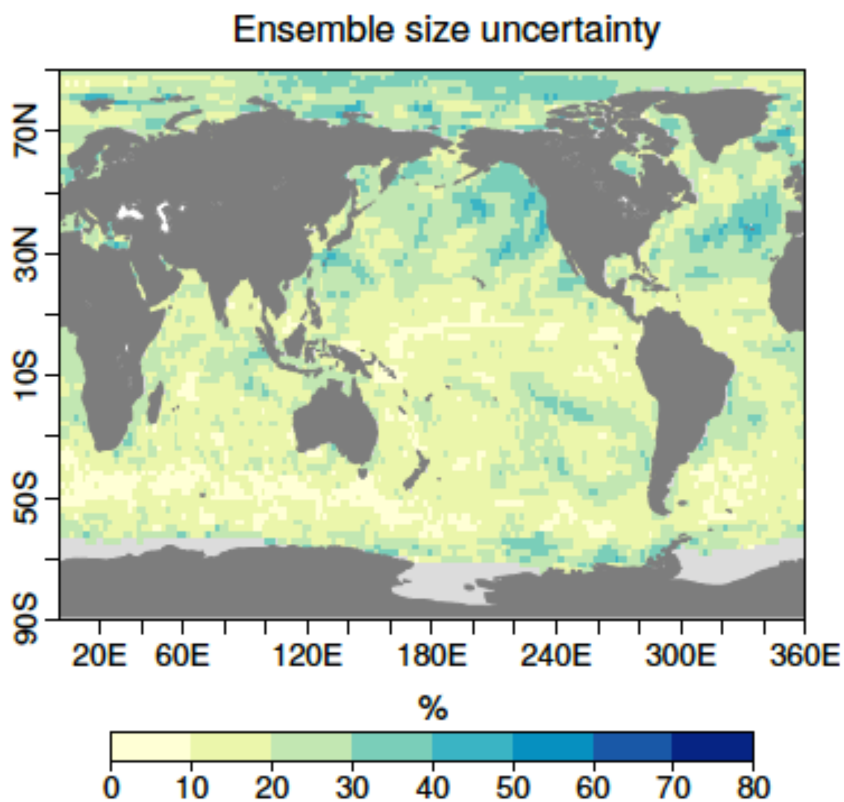
ESA CCI Uncertainty estimate





Relative contributions





Introduction: Research at BSC

Improving capabilities of seasonal-to-decadal predictions